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ABSTRACT

Thirty-one championship caliber women athletes participating on varsity teams at Ohio State University were trained using two different conditioning programs, in an attempt to determine the physiological outcomes of weight training versus cardiovascular-oriented conditioning. Fourteen tennis players followed a program of high-resistance weight training; 19 basketball players used a program emphasizing cardiovascular-endurance activities. Results, largely presented in tabular form, illustrate changes in body composition, muscle girths, and strength, based on t-test analysis methods. Small decreases were found on all of the muscle girth measures for both teams. Neither training program resulted in evident muscle hypertrophy, and the percentage of body fat became relatively equal between teams by the termination of the program. Both teams showed significant lower extremity strength gains. (Author/LH)

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CHANGES IN BODY COMPOSITION
AND STRENGTH OF FEMALE ATHLETES
ON TWO DIFFERENT TRAINING PROGRAMS

U.S. DEPARTMENT OF HEALTH,
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Abstract

Thirty-one championship caliber women athletes participating on women's varsity teams at the Ohio State University were trained using two different conditioning programs. Fourteen tennis players followed a program of high-resistance weight-training using the Nautilus weight-lifting machines for seven weeks. The 19 basketball players used a program emphasizing cardiovascular-endurance activities.

Changes in body composition, muscle girths and strength were compared using the t-test. Decreases, although small, were found on all of the muscle girth measures for both teams. There was no evidence of muscle hypertrophy as a result of either training program. At the beginning of the programs, the tennis team had a significantly higher percent of body fat than the basketball team, but after training, this difference was no longer significant. The body fat percentage of the tennis team was reduced, while that of the basketball team increased.

Each team showed significant lower extremity strength gains.

A COMPARATIVE STUDY OF STRENGTH AND BODY COMPOSITION CHANGES IN COLLEGE FEMALE ATHLETES ON TWO DIFFERENT TRAINING PROGRAMS

There has been a recent surge of interest in the female athlete and her competitive opportunities. Her needs, characteristics and conditioning cannot, and should not, be inferred from generalizations from studies of her male counterpart. It is well established that very real physiological differences exist between the sexes, yet a review of the number of hours spent on conditioning and the types of training programs shows that women are following men's programs very closely.

It was the purpose of this study to compare changes in body composition and strength of women athletes participating on teams at the Ohio State University using two different training programs. Changes within each team were compared as well as a cross-team comparison.

Review of Literature

It is difficult to compare effects of a season of competition with effects of training with weight-training programs because of discrepancies in measurements taken by different observers. No study was found comparing the two programs by one administrator.

Results of studies using either weight training or activity training have been conflicting and nonconclusive as to their effects on body composition and muscle hypertrophy. Most of the studies dealing with effects of the activity training have not been concerned with strength changes.

Lundegren (1968) and Diehl (1974) found significant reductions in fat measures, as determined by skinfold, in women varsity basketball players with no accompanying change in body weight after approximately 10 weeks of training. On the other hand, Katch, Michael and Jones (1969) found no significant changes in body fat or any of the body composition measures in tennis players following a 16-week sports training program. They concluded that the physical activity by the female athletes had little effect on body composition without dietary control. Sinning (1970) found small, but statistically significant changes in body composition which were accompanied by slight weight and lean body mass increases.

Whereas, reports of training studies emphasized changes in body composition, studies using high-resistance weight training emphasized strength and girth changes. All weight training studies (Mayhew, 1974; Broton and Wilmore, 1973; Capen, Bright, and Line, 1961; Wells, Jokl, and Bohanen, 1963; Wilmore, 1975) reported significant strength gains but contradictory results were reported on girth changes. Brown and Wilmore (1973) found 3 - 5% gains in arm girths, Capen (1961) and Wells (1963) found little or no muscular hypertrophy (but similar strength gains to Brown and Wilmore). Wilmore (1974), studying non-athletes, found only slight muscular hypertrophy while Mayhew and Gross (1974) found increased girth measurements in the upper extremity but not in the legs.

Procedure

Thirty-one women athletes currently participating on varsity teams at the Ohio State University volunteered to serve as subjects for the study. There were 14 tennis players and 19 basketball players.

Athletes were chosen for this study not only because of the current upsurge of interest in the female athlete and the dearth of information concerning her but also because the fact that these women were champions playing on championship teams implies a physical condition superior to that of a member of the normal population. Therefore one of the basic assumptions of this study was that any changes in strength or body composition during either of the training programs must be due to the program itself. None of the athletes studied went on a special diet or participated in any supplementary exercise program during the training periods. Thus the subjects served as their own controls for this study.

During the winter-quarter "off-season" the women tennis players followed a program of progressive high-resistance exercises on the Nautilus machines and were tested before beginning the program and within one week after the program was discontinued. The women lifted weights twice a week for seven weeks.

Each exercise session involved a circuit of the Nautilus stations involving torso exercises, arm, shoulder, hip and knee exercises. Weights were progressively increased so that the subject was not able to perform a full repetition of a weight-lift within 10 repetitions at each of the stations.

The basketball players were tested before and after the regular basketball season. The workouts consisted of circuit-training exercises with no attempt at a high resistance weight training program during the season. Emphasis was on cardiovascular endurance activities,

Four skinfold measures were taken according to the Fels Research Institute Methods at iliac crest, subscapular, triceps and medial calf sites. In addition, the iliac crest and triceps measures were used to determine body density and percent body fat from the Sloan-Weir (1970) nomogram. Girth measurements were taken of the flexed and relaxed upper and lower arm, inspired and relaxed chest, the abducted deltoid, the thigh below the gluteal fold and the medial calf at its largest circumference.

Strength measures of shoulder flexion and extension, elbow flexion and extension, hip flexion, ankle plantar flexion were taken using the Clarke (1953) cable-tension method. In addition the strength measures of shoulder flexion, hip flexion, and ankle plantar flexion were summed to form the strength composite. The strength composite was found by Becker (1967) to have a multiple correlation of .947 with 25 measures of strength in college women.

Analysis and Interpretation of the Data

Pre- and post-test means and standard deviations were computed for each of the teams on each of the variables (Tables 1 and 2). Decreases, although small, are noticeable on all of the girth measurements for both teams. Similar decreases were found in most of the skinfold measures, however the mean subscapular skinfold of the tennis team increased by .07 mm. The only other skinfold increase was the iliac crest measure on the basketball team. This iliac crest skinfold increase is again reflected in the increased percent body fat means for the basketball team. The basketball team also showed a slight weight gain. Increases in lower extremity and shoulder flexion strength for both teams were most apparent and hence the increase in the strength composite.

TABLE 1
PRE - POST TEST COMPARISONS

t-TEST

BASKETBALL TEAM

<u>GIRTH MEASUREMENTS</u>		<u>MEAN</u>	<u>S.D.</u>	<u>SEM</u>	<u>t</u>
Upper Arm Flexed	PRE	28.02cm.	1.19	.27	-1.50
	POST	27.42cm.	1.29	.29	
Upper Arm Relaxed	PRE	27.07cm.	1.21	.28	-1.68
	POST	26.37cm.	1.35	.31	
Forearm Flexed	PRE	24.87cm.	1.07	.25	-1.76
	POST	24.27cm.	1.05	.24	
Forearm Relaxed	PRE	24.47cm.	1.05	.24	-2.84*
	POST	23.53cm.	0.99	.23	
Deltoid	PRE	33.15cm.	3.45	.79	-0.19
	POST	32.98cm.	1.98	.45	
Inspired Chest	PRE	90.10cm.	3.31	.76	-1.10
	POST	88.86cm.	3.60	.83	
Relaxed Chest	PRE	87.03cm.	3.47	.80	-0.80
	POST	86.11cm.	3.67	.84	
Thigh	PRE	57.67cm.	2.98	.68	-0.45
	POST	57.26cm.	2.62	.60	
Calf	PRE	36.89cm.	2.19	.50	-1.27
	POST	35.98cm.	2.25	.52	
<u>SKINFOLDS</u>					
Subscapular	PRE	11.55mm	3.15	1.72	-0.80
	POST	10.72mm	3.28	.75	
Iliac Crest	PRE	17.38mm	4.17	.96	2.45*
	POST	21.48mm	5.97	1.37	
Triceps	PRE	17.89mm	3.86	.89	-1.93
	POST	15.60mm	3.42	.78	

*Significant at .05 LOC

TABLE 1
CONTINUED

<u>SKINFOLDS</u>		<u>MEAN</u>	<u>S.D.</u>	<u>SEM</u>	<u>t</u>
Calf	PRE	13.80mm	3.41	.78	-0.08
	POST	13.72mm	2.94	.67	
%Body Fat	PRE	22.51%	2.41	.55	0.79
	POST	23.17%	2.73	.63	
Weight	PRE	143.25lbs.	13.58	3.12	0.21
	POST	144.18lbs.	13.80	3.17	
<u>STRENGTH</u>					
Shoulder Flexed	PRE	68.36lbs.	13.82	3.17	0.47
	POST	70.35lbs.	12.24	2.81	
Shoulder Extended	PRE	78.16lbs.	13.35	3.06	-0.97
	POST	74.12lbs.	12.29	2.82	
Elbow Flexed	PRE	87.58lbs.	23.18	5.32	-0.66
	POST	83.20lbs.	17.00	3.90	
Elbow Extended	PRE	49.95lbs.	10.27	2.36	-1.60
	POST	45.18lbs.	7.97	1.83	
Hip Flexed	PRE	69.78lbs.	27.95	6.41	5.44*
	POST	119.64lbs.	28.56	6.55	
Ankle Plantar Flexed	PRE	185.23lbs.	45.18	10.36	4.80*
	POST	253.64lbs.	42.66	9.79	
Strength Comparison	PRE	323.37lbs.	60.35	13.84	6.13*
	POST	431.61lbs.	47.78	10.96	

TABLE 2
PRE - POST TEST COMPARISONS

t-TEST

TENNIS TEAM

<u>GIRTH MEASUREMENTS</u>		<u>MEAN</u>	<u>S.D.</u>	<u>SEM</u>	<u>t</u>
Upper Arm Flexed	PRE	27.46cm.	2.37	0.68	-0.29
	POST	27.20cm.	1.91	0.55	
Upper Arm Relaxed	PRE	26.56cm.	2.50	0.72	-0.33
	POST	26.24cm.	2.17	0.63	
Forearm Flexed	PRE	25.08cm.	1.50	0.43	-0.83
	POST	24.58cm.	1.44	0.42	
Forearm Relaxed	PRE	24.63cm.	1.58	0.46	-0.98
	POST	24.03cm.	1.47	0.42	
Deltoid	PRE	35.74cm.	3.53	1.02	-0.25
	POST	35.41cm.	3.05	0.88	
Inspired Chest	PRE	87.54cm.	6.49	1.87	-0.48
	POST	86.33cm.	5.81	1.68	
Relaxed Chest	PRE	85.55cm.	6.36	1.84	-0.43
	POST	84.51cm.	5.43	1.57	
Thigh	PRE	56.41cm.	4.91	1.42	-0.49
	POST	55.40cm.	5.22	1.51	
Calf	PRE	35.92cm.	3.05	0.88	-1.00
	POST	34.83cm.	2.27	0.66	
<u>SKINFOLDS</u>					
Subscapular	PRE	14.61mm	5.31	1.53	0.03
	POST	14.68mm	4.20	1.21	
Iliac Crest	PRE	24.25mm	9.01	2.60	-0.83
	POST	21.63mm	6.33	1.83	
Triceps	PRE	21.19mm	5.82	1.68	-0.32
	POST	20.46mm	5.24	1.51	
Calf	PRE	16.05mm	6.23	1.80	-0.62
	POST	14.65mm	4.81	1.39	
%Body Fat	PRE	25.95	5.25	1.52	-0.56
	POST	24.93	3.42	0.99	

TABLE 2
CONTINUED

<u>SKINFOLDS</u>		<u>MEAN</u>	<u>S.D.</u>	<u>SEM</u>	<u>t</u>
Weight	PRE	137.83lbs.	22.46	6.48	-0.05
	POST	137.44lbs.	20.21	5.83	
<u>STRENGTH</u>					
Shoulder Flexed	PRE	65.71lbs.	11.42	3.30	0.66
	POST	69.24lbs.	14.52	4.19	
Shoulder Extended	PRE	74.37lbs.	18.15	5.24	0.04
	POST	74.72lbs.	21.52	6.21	
Elbow Flexed	PRE	104.38lbs.	25.32	7.31	-0.91
	POST	94.86lbs.	25.83	7.46	
Elbow Extended	PRE	50.41lbs.	10.37	2.99	-0.50
	POST	47.90lbs.	13.77	3.97	
Hip Flexed	PRE	99.93lbs.	13.65	3.94	1.95
	POST	120.47lbs.	33.80	9.76	
Ankle Plantar Flexed	PRE	194.16lbs.	51.25	14.79	2.72*
	POST	246.67lbs.	42.82	12.36	
Strength Composite	PRE	361.05lbs.	65.63	18.94	2.85*
	POST	436.38lbs.	63.79	18.41	

Shoulder extension strength increased slightly on the tennis team but decreased on the basketball team. Both teams showed decreases on both measures of elbow strength. Shoulder extension strength of the basketball team decreased but the tennis team showed an increase, although not significant on this measure. Lower extremity strength measures increased for both teams.

Before any statement could be made concerning the effectiveness of the training programs it was necessary to make a comparison of the pre-post test differences for each of the teams. This was accomplished through use of the t-test. (Tables 1 & 2.)

Since the standard error was high in some instances, the F-value of the variance was computed. If the F-value was significant (.05), the t of the separate variance estimate was used. If the F-value of the variance was not significant the pooled variance estimate was used with 36 degrees of freedom for the basketball team and 22 degrees of freedom for the tennis team. The separate variance estimate reduces the number of degrees of freedom to allow for larger differences in the standard deviations. The .05 level of significance was accepted.

Each of the teams showed decreases in all girth measurements. The relaxed forearm girth of the basketball team decreased significantly. The skinfold measures on each of the teams showed similar decreases except for the iliac crest measure of the basketball team which not only increased but increased significantly. This team also showed a weight gain but not a significant one.

None of the upper extremity strength measures showed significant pre-post test differences or significant differences on either team.

TABLE 3
COMPARISON OF PRE - TEST AND POST - TEST
MEANS AND STANDARD DEVIATIONS
OF GIRTH, SKINFOLD & STRENGTH MEASURES
FOR BOTH TEAMS

<u>VARIABLES</u>	<u>TEAM</u>	<u>PRE-TEST</u>		<u>POST-TEST</u>	
<u>Girth Measurements</u>		<u>M.</u>	<u>S.D.</u>	<u>M.</u>	<u>S.D.</u>
Upper Arm Flex	T.	27.46cm	2.37	27.20	1.91
	B.	28.02cm	1.19	27.42	1.28
Upper Arm Relaxed	T.	26.56cm	2.50	26.24	2.17
	B.	27.07cm	1.21	26.37	1.35
Forearm Flex	T.	25.07cm	1.50	24.57	1.44
	B.	24.87cm	1.07	24.27	1.05
Forearm Relaxed	T.	24.63cm	1.58	24.02	1.47
	B.	24.47cm	1.05	23.53	0.99
Deltoid	T.	35.74cm	3.53	35.41	3.05
	B.	33.15cm	3.45	32.98	1.97
Inspired Chest	T.	86.54cm	6.49	86.33	5.81
	B.	90.10cm	3.51	88.86	3.60
Relaxed Chest	T.	85.55cm	6.36	84.51	5.43
	B.	87.03cm	3.47	86.11	3.67
Thigh	T.	56.41cm	4.91	55.40	5.22
	B.	57.67cm	2.98	57.26	2.62
Calf	T.	35.92cm	3.03	34.83	2.27
	B.	36.87cm	2.19	35.98	2.25
<u>Skinfolds</u>					
Subscapular	T.	14.61mm	5.31	14.68	4.20
	B.	11.55mm	3.16	10.72	3.28
Iliac Crest	T.	24.25mm	9.01	21.63	6.33
	B.	17.38mm	4.17	21.48	5.97
Triceps	T.	21.19mm	5.82	20.46	5.24
	B.	17.89mm	3.86	15.61	3.42
Calf	T.	16.05mm	6.23	14.65	4.81
	B.	13.80mm	3.41	13.72	2.94

TABLE 3
CONTINUED

<u>VARIABLES</u>	<u>TEAM</u>	<u>PRE-TEST</u>		<u>POST-TEST</u>	
<u>Skinfolds</u>		<u>M.</u>	<u>S.D.</u>	<u>M.</u>	<u>S.D.</u>
% Body Fat	T.	25.95%	5.25	24.93	3.42
	B.	22.51%	2.41	23.17	2.73
Weight	T.	137.83 lbs.	22.46	137.44	20.21
	B.	143.25 lbs.	13.58	144.18	13.80
Height	T.	165.41cm	7.65		
	B.	171.83cm	7.05		
<u>Strength</u>					
Shoulder Flex	T.	65.71 lbs.	11.42	69.24	14.32
	B.	68.36 lbs.	13.82	70.35	12.24
Shoulder Ext.	T.	74.37 lbs.	18.15	74.72	21.52
	B.	78.16 lbs.	13.35	74.12	12.29
Elbow Flex	T.	104.38 lbs.	25.32	94.86	25.83
	B.	87.58 lbs.	23.18	83.20	17.00
Elbow Ext.	T.	50.41 lbs.	10.37	47.90	13.77
	B.	49.95 lbs.	10.27	45.18	7.97
Hip Flex	T.	99.93 lbs.	13.65	120.48	33.80
	B.	69.78 lbs.	27.95	119.60	28.56
Ankle P. Flex	T.	194.16lbs.	51.25	246.67	42.82
	B.	185.23lbs.	45.18	253.64	42.66
Strength Comp.	T.	361.05lbs.	65.63	436.38	63.79
	B.	323.38lbs.	60.37	431.61	47.78

TABLE 4

COMPARISON OF THE TENNIS AND
BASKETBALL TEAMS ON GIRTH, SKINFOLD AND
STRENGTH MEASURES ON THE PRE-TEST

PRE-TEST t

Variables	Team**	Variance	Pooled Variance		Separate Variance		
		F-Value	t	Probability	df	t	Probability
Girth							
Upper Arm flex	B	3.99*			14.5	0.76	0.46
Upper Arm Rlx	B	4.32*			14.3	0.67	0.52
L. Arm Flex	T	1.96	-0.44	0.67			
L. Arm Rlx	T	2.25	-0.35	0.73			
Deltoid	T	1.05	-2.02	0.05*			
Chest Insp	B	3.86*			14.7	1.27	0.23
Chest Rlx	B	3.36	0.84	0.41			
Thigh	B	2.72	0.89	0.38			
Calf	B	1.92	1.04	0.31			
Skinfolds							
Subscap	T	2.83*			16.0	-1.80	0.09
Iliac	T	4.67*			14.0	-2.48	0.03*
Triceps	T	2.27	-1.91	0.07			
Calf	T	3.33*			15.2	-1.15	0.27
Pct Body Fat	T	4.75*			14.0	-2.13	0.05*
Mt.	B	1.36	2.33	0.03*			
Wt.	B	2.73	0.84	0.41			
Strength							
Shldr Flxn	B	1.46	0.55	0.58			
Shldr Exn	B	1.85	0.67	0.51			
Elb. Flxn	T	1.19	-1.90	0.07			
Elb. Exn	T	1.02	-0.12	0.91			
Hip Flxn	T	4.19*			27.7	-4.01	0.01*
Ankl P. Flxn	T	1.29	-0.51	0.61			
Stren. Comp.	T	1.18	-1.64	0.11			

df for Pooled Variance = 29

* Sig. at .05

** Indicates team having higher mean (T=Tennis, B=Basketball)

TABLE 5

A COMPARISON OF THE TEAMS
ON GIRTH, SKINFOLD AND
STRENGTH MEASURES ON THE
POST-TEST

Variables	Team**	Variance F-Value	POST-TEST t		Separate Variance		
			Pooled t	Variance Probability	df	t	Probability
<u>Girth</u>							
Bic. Flex	B	2.22	0.38	0.71			
Bic. Rlx	B	2.58	0.21	0.84			
L. Arm Flx	T	1.89	-0.69	0.50			
L. Arm Rlx	T	2.19	-1.13	0.27			
Belt.	T	2.40	-2.71	0.01*			
Chest Insp	B	2.60	1.50	0.14			
Chest Rlx	B	2.18	0.98	0.33			
Thigh	B	3.96*			14.6	1.15	0.27
Calf	B	1.02	1.39	0.18			
<u>Skinfolds</u>							
Subscap	T	1.64	-2.94	0.01*			
Iliac	T	1.12	-0.06	0.95			
Triceps	T	2.35	-3.13	0.00*			
Calf	T	2.68	-0.67	0.51			
Pct Body Fat	T	1.57	-1.59	0.12			
Ht.	B	1.36	2.33	0.03*			
Wt.	B	2.14	1.11	0.28			
<u>Strength</u>							
Shldr Flxn	B	1.41	1.41	0.82			
Shldr Exn	T	3.07*			15.6	-0.09	0.93
Elb. Flxn	T	2.31	-1.52	0.14			
Elb. Exn	T	2.98*			15.7	-0.62	0.54
Hip Flxn	T	1.40	-0.07	0.94			
Ankle P. Flxn	B	1.01	0.44	0.66			
Stren. Comp.	T	1.78	-0.24	0.81			

df for Pooled Variance = 29

* Sig. at .05

** Team having higher mean

The hip flexor strength gains were significant for the basketball team. An inspection of the means showed much greater strength gains for the basketball team than the tennis team, but a much lower pre-test score and much greater variability in the scores. It would appear that each of the programs was effective in increasing hip flexor strength.

Each of the teams showed significant pre-post test gains on both ankle plantar flexion strength and the strength composite score.

Separate comparisons were made of the two groups on the pre-tests and the post-tests using the t-test. A comparison of the pre-test and post-test means and standard deviations of each of the teams is presented in table 3. Tables 4 and 5 show Pre-test and Post-test comparisons via the t-test.

If the F-value of the variance was significant, the t of the separate variance estimate was used. If the F-value of the variance was not significant, the t value of the pooled variance estimate was used with 29 degrees of freedom. The .05 level of significance was accepted.

As would be expected the tennis team had greater lower arm and deltoid girth measurements. These were accompanied by greater elbow flexion and extension strength. However, none of these differences was significant. The greater calf girth measure of the basketball team was not reflected in the ankle plantar flexion strength score. On the pre-test, the tennis team had stronger ankle plantar flexors whereas on the post test the basketball team was superior. Again, none of these differences were significant.

On the pre-test the teams were significantly different on deltoid girth, iliac skinfold, percent body fat, height and hip flexor strength.

Post-test comparisons showed the teams were still significantly different in height and deltoid girth. However, skinfold differences

were no longer apparent at the iliac crest but at the skinfolds subscapular and triceps areas were now significant. In fact, the post-test iliac crest skinfold means were essentially equal. The percent body fat difference was no longer significant, therefore changes in the triceps skinfold measure were not great enough to represent a change in the body fat with the equalization of iliac crest differences.

Although the tennis team had significantly stronger hip flexors before the training programs, these differences were no longer apparent at the post-test. Once again the post-test means were essentially equal.

It is also interesting to note that although each of the teams showed significant pre-post test gains on both ankle plantar flexor strength and on the strength composite score, the differences between the teams was not significant on either the pre-test or post-test comparisons.

Conclusions

The tennis team trained on the Nautilus machine for 7 weeks of high intensity weight training. The basketball team used a predominantly cardiovascular endurance-type training program.

Decreases, although small, were found on all muscle girth measures for both teams. There was no evidence of muscle hypertrophy as a result of either training program.

The team on the endurance training program showed decreases in triceps and subscapularis skinfold measures with accompanying decreases in upper arm and chest girth measurements. However, significant increases were found in the iliac crest skinfold measures. The team on the weight training program showed no significant skinfold differences on any of the measures.

Pre-training comparisons showed the tennis team to have a significantly larger iliac crest skinfold diameter than the basketball team but post-training comparisons showed the teams to have essentially equal iliac skinfold diameters.

Pre-training means of the subscapular and triceps skinfold measures showed the tennis team had larger, but not significant, skinfold diameters. Differences on these measures after training were significant between the teams. Both teams showed decreases in these measures. The decrease of the basketball team was significant.

It would appear that the endurance-type program produced greater decreases in upper body skinfold measures at the triceps and subscapular sites while increasing fat deposits were found at the iliac sites. The weight-training program produced decreases on all the skinfold measures, although none of these decreases was significant. All pre-test measures for the tennis team were greater than those of the basketball team.

At the beginning of the training programs, the tennis team had a significantly higher percent of body fat than the basketball team but after training, this difference was no longer significant. The body fat percentage of the tennis team was reduced while that of the basketball team increased. Neither of these pre-post changes was significant so it is not possible to support the weight-training program as more effective in decreasing body fat.

None of the upper extremity strength measures showed significant gains for either team.

Each of the teams showed significant lower extremity strength gains. While the tennis team had significantly stronger hip flexors on the pre-test than the basketball team, post-test means were essentially equal.

Both teams showed significant plantar flexor strength gains. These strength gains were accompanied by decreases in calf girth measurements,

but little or no change in calf skinfold measures. Significant strength gains with no concomitant muscle hypertrophy but actual decrease in muscle size are apparent. Other investigators have reported strength gains with varying degrees of hypertrophy or no hypertrophy, but none are known to have reported significant decreases in muscle size without significant change in the skinfold measures. Both training programs produced these results. No significant differences between the teams were found in either the pre-test or the post-test results.

Although many changes in the girth, skinfold and strength variables used in this study occurred as a result of the two training programs, it is impossible to support one of the programs over the other as producing more favorable changes among these variables.